Using Total Lightning Information at WFO Melbourne

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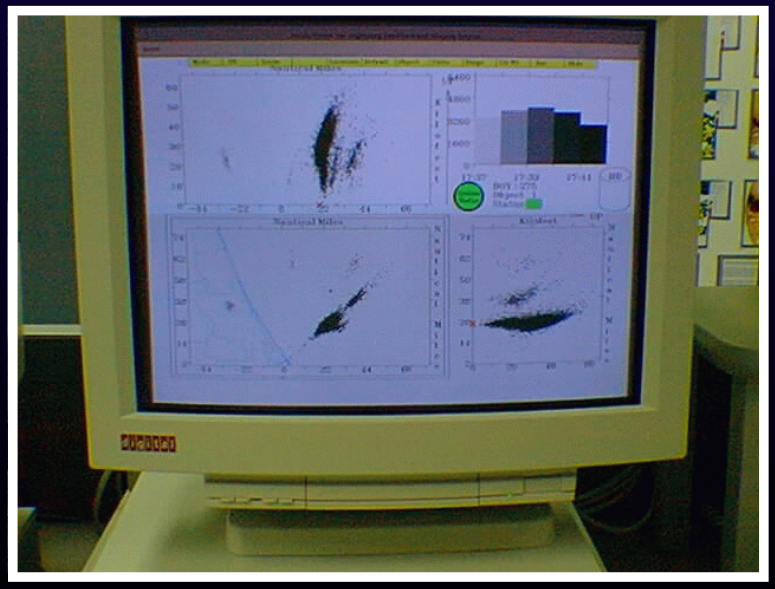
History & Background

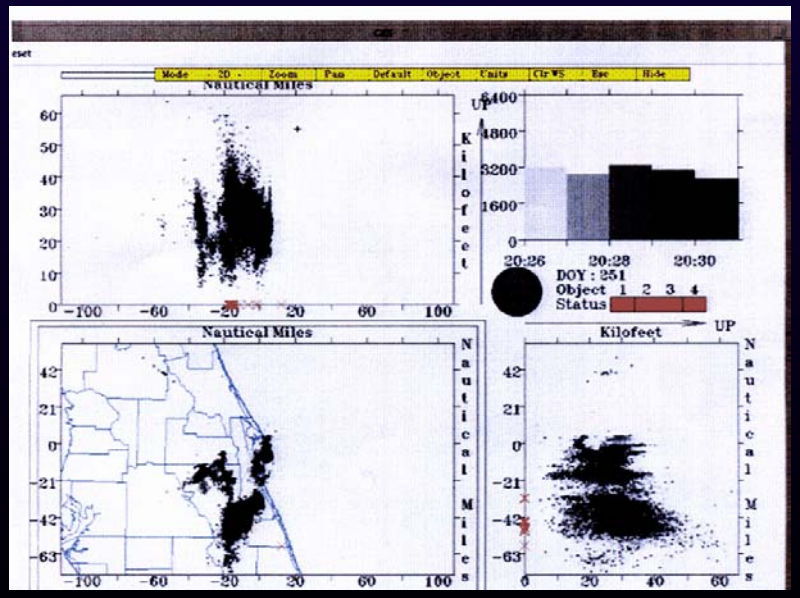
- TOA CG data in 1989.
- LDAR since 1994. *
- LISDAD since 1997. *
- NLDN since 1998.

* Showing positive value of NOAA/NWS collaborations with NASA.



Current Situation

- Operational experience with TLI for over 10 years (along with SMG & 45th WS).
- At NASA/KSC...LDAR will soon be upgraded to LDAR II with no contingent to continue data supply.
- Original LISDAD is all but defunct.
- Other WFOs acquiring access to TLI.



Solving Forecast & Warning Problems With Science & Technology

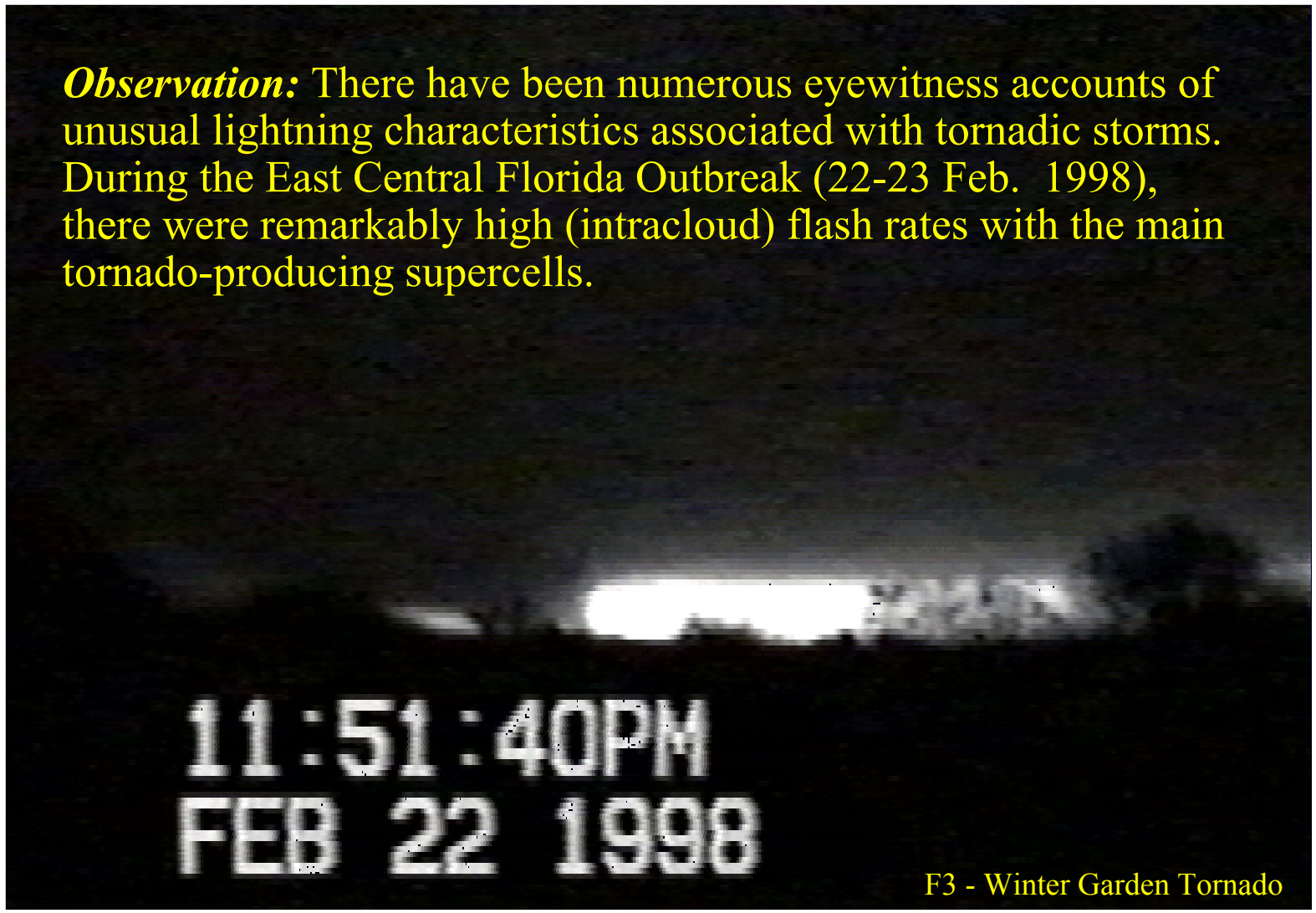
- Severe Storm Discernment
- Enhanced Short-term Aviation Forecasts
- Lightning Information in Public Products

Addressing the...

* Agency mission to reduce loss of life and property from adverse weather, while supporting the nation's economic interests.
* NWS Strategic Plan for improvement of products & services.

Severe Storm Discernment

Observation: There have been numerous eyewitness accounts of unusual lightning characteristics associated with tornadic storms. During the East Central Florida Outbreak (22-23 Feb. 1998), there were remarkably high (intracloud) flash rates with the main tornado-producing supercells.



F3 - Winter Garden Tornado

Lightning: A Non-traditional Data Set

A salesman's approach...POD, FAR, Lead Time.

The continuing NWS challenge*...*to discern severe storms from non-severe storms (even tornadic from non-tornadic) in a timely manner. This is the #1 operational priority.

This is a function of ***"confidence"*** in which the warning meteorologist should integrate and use ***any/all*** available information

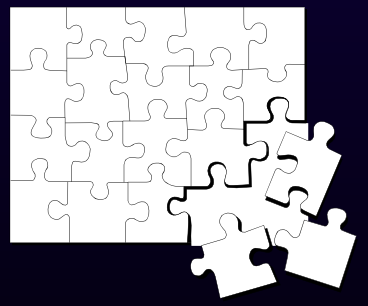
...including lightning*.*

A Thunderstorm's Character

A lawyer's approach...making a case to forecasters.

Operationally...a severe storm's character is determined through the rapid and continual ***preponderance of meteorological evidence*** (all available information), often in the ***absence of confirmation*** (an observation or report), but relative to the accuracy of our ***conceptual model*** (our mental standard).

- Radar Data (including new VCPs)
- Satellite Data (including rapid scan)
- Lightning Data (including TLI)



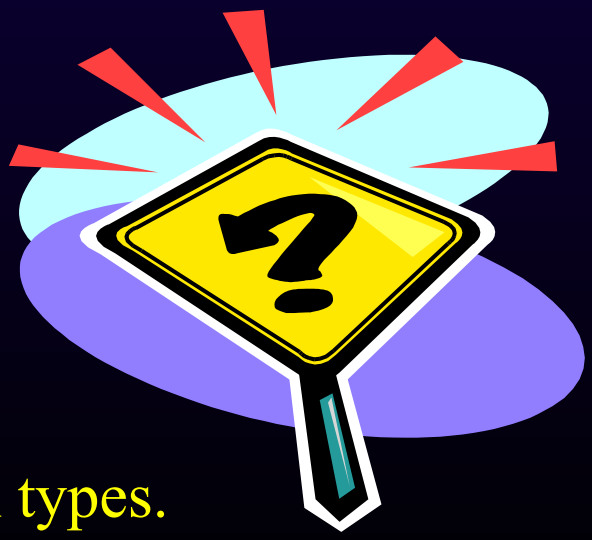
Severe ?
Non-Severe ?

This is dependent upon what ***we see*** (sample) biased by what ***we expect to see*** (conceptual model of storm structure).

The Obvious Questions

Currently, most field forecasters want to know...

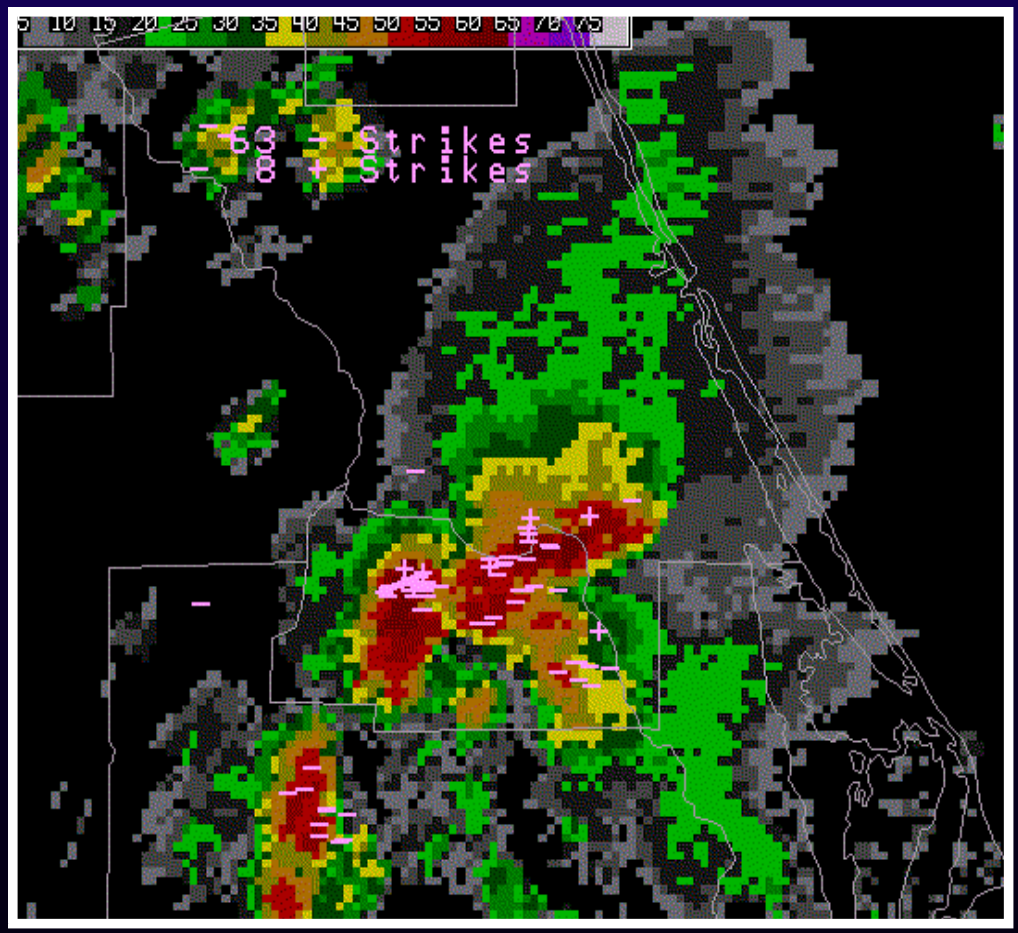
- How can total lightning information factor in to our conceptual model(s) for severe thunderstorms?
- How can total lightning information aid in the warning decision making process?



These questions are valid for all varying storm types.

CG Data Alone - A Narrow View

- 1-hr, 15 min, 5 min, 1 min plots of CG.
- Polarity information.
- Integrate with radar and satellite data.
- Some association to individual storms.
- Trend information in the form of animated loops.



"A narrow view of lightning data applications"

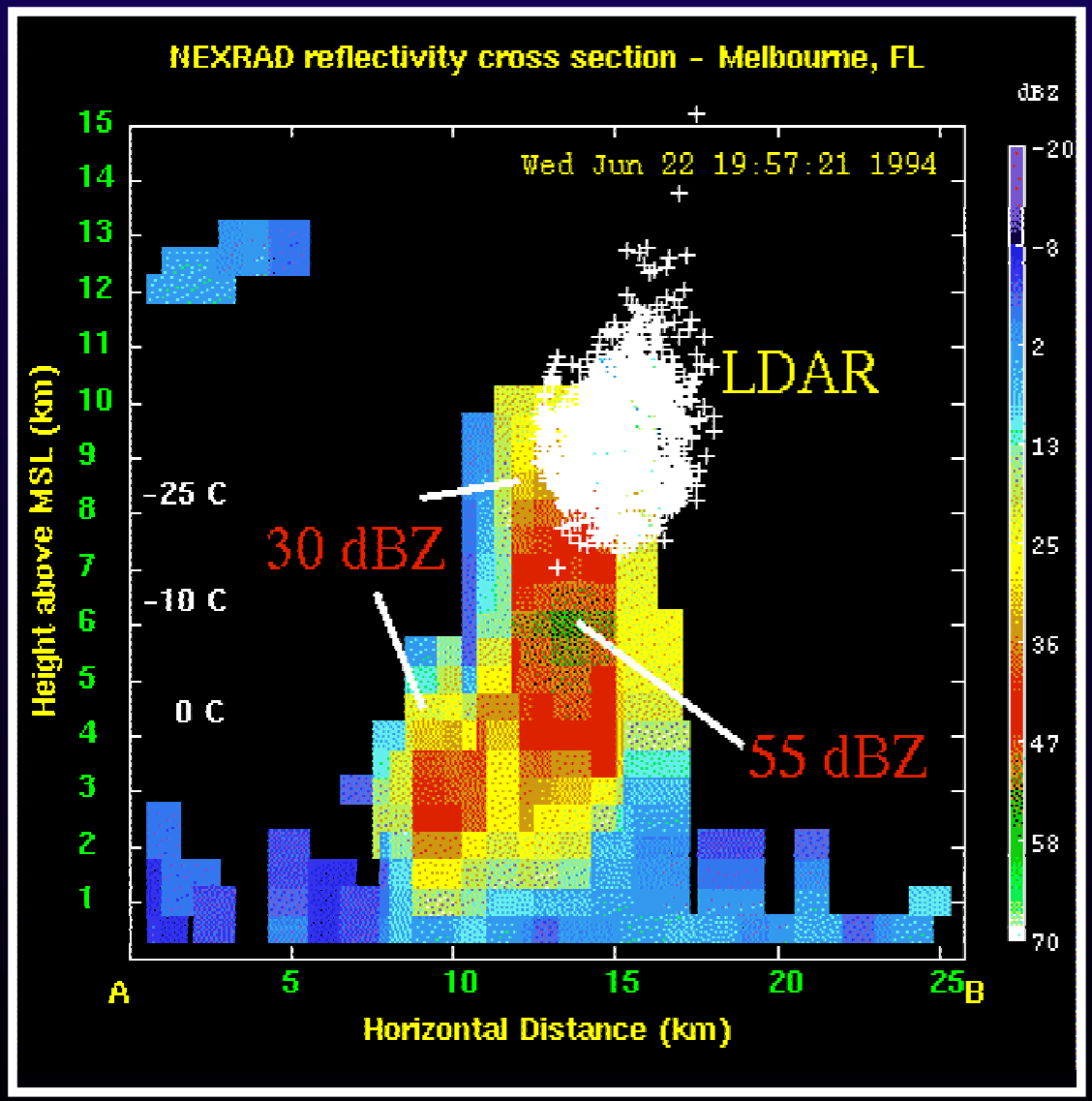
Assessment of Updraft Strength

Since the use of CG information has been shown to have some value, a greater case can be made for the use of total lightning information.

- ***CG lightning comprises a smaller percentage*** of the total lightning signal (a point often underappreciated by the field).
- The ***intracloud signal*** is more sensitive to changes in the updraft, especially in vicinity of the updraft core (edges) itself.
- When used in conjunction with radar data, it can be associated (directly or indirectly) with a specific storm and trended to provide an ***additional proxy quantity*** to assess the relative updraft character at a certain time.
- Main caveats to direct association through "flashes":
  - translate point source information into a "flash"
  - associate a flash with a particular storm
  - accounting for location error and overlap

Initial Storm Electrification

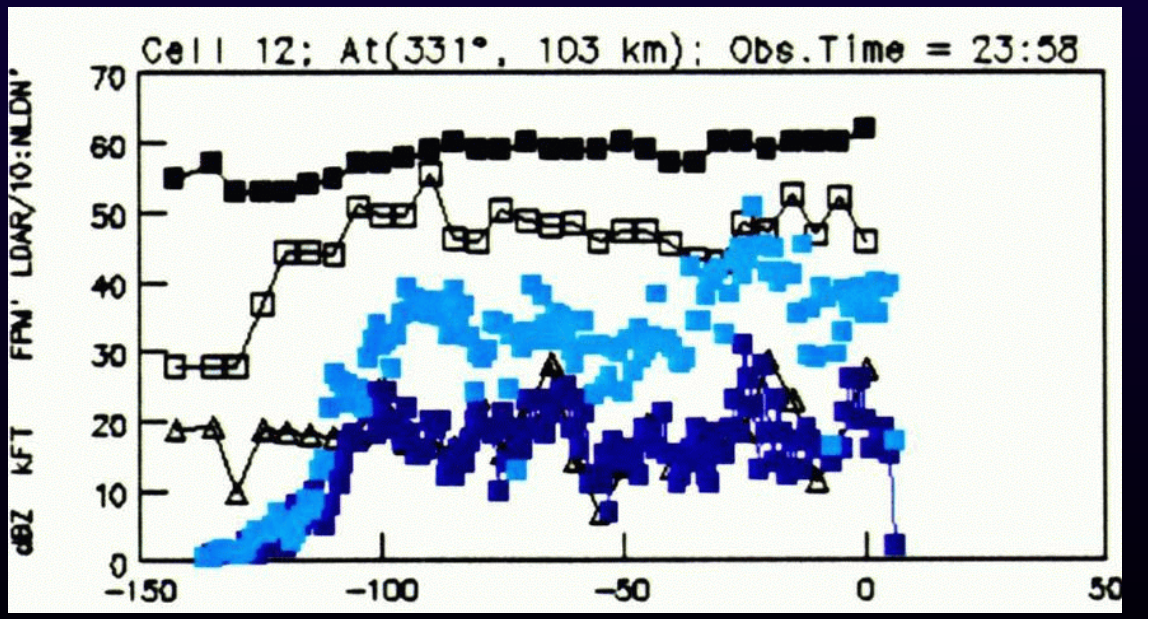
- IC precedes CG by average 4-5 minutes (but 1st CG within 1 min of IC in about 25% storms).
- Initial IC often above and along edges of updraft core.



Forbes, Hoffert, & Pearce

Pulse Severe Storms

- Hazards
  - damaging winds (microbursts)
  - large hail
- Warning Dilemma
  - inherent short lead-time
- Application
  - discern severe from non-severe
  - increase warning lead-time
- Signals
  - minimum threshold
  - lightning “jump”
  - lightning “drop”



Date: July 7 1997
LISDAD Image: 2358 UTC
Severe Weather: **Wind and Hail damage across Volusia county.**
2335 UTC: Stadium power poles down.
2350 UTC: golfball hail report.
0020 UTC: Trees and power poles down.
Warning Issued: 2253 UTC (-65 minutes on plot...re-issued at 2355 UTC)
LDAR FPM Scale: ..... FPM x **10** (IC)
NLDN FPM Scale: ..... FPM x **1**

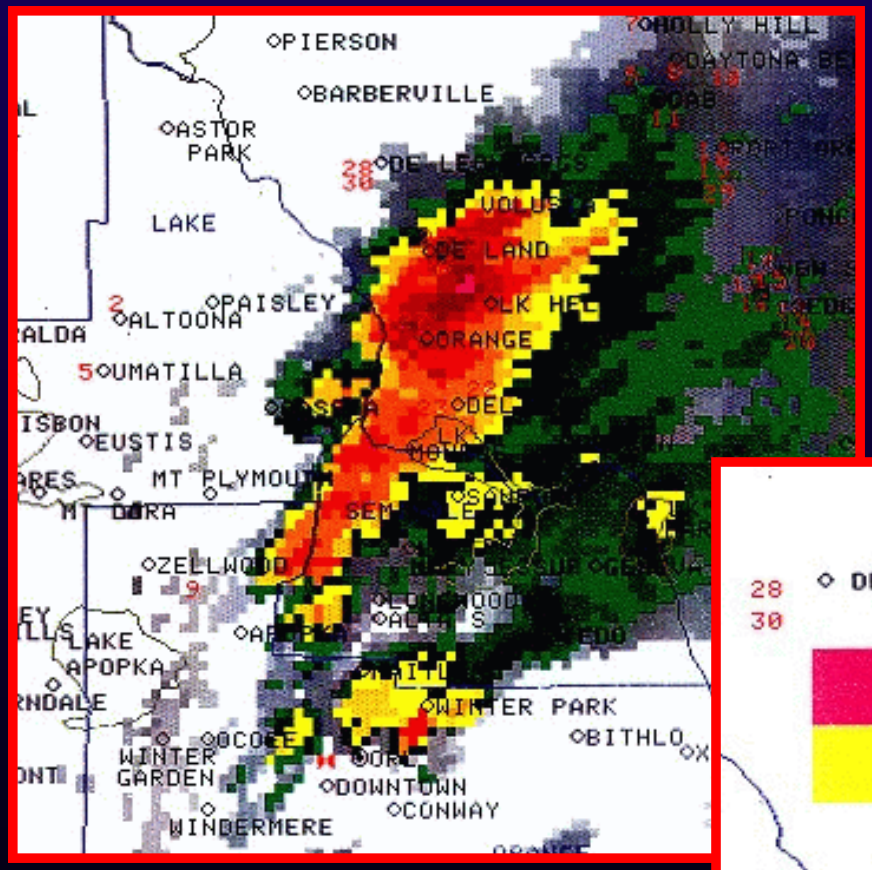
Cell developed on ***sea breeze boundary*** and moved (propagated) SSW through Volusia county. Cell remained relatively isolated through most of its life.

Cell produced ***IC of 300+ FPM for >1.5 h*** and ***450+ FPM for ~10 min***!
CG strikes averaged ***~20 FPM for over 100 min***!

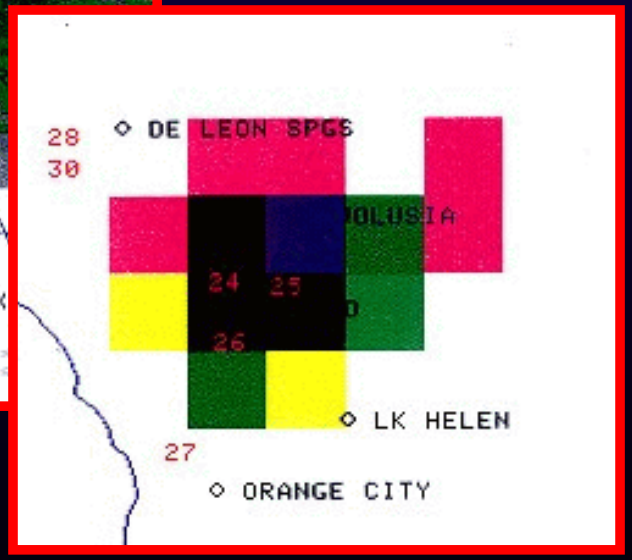
Summary of lightning increase:

Rapid increase began:	2203 UTC
Rapid increase ended:	2210 UTC (+85 minute lead time)
Warning Issued:	2253 UTC (+42 minute lead time)
First severe weather report:	2335 UTC

19 September, 2000 - Pulse Severe



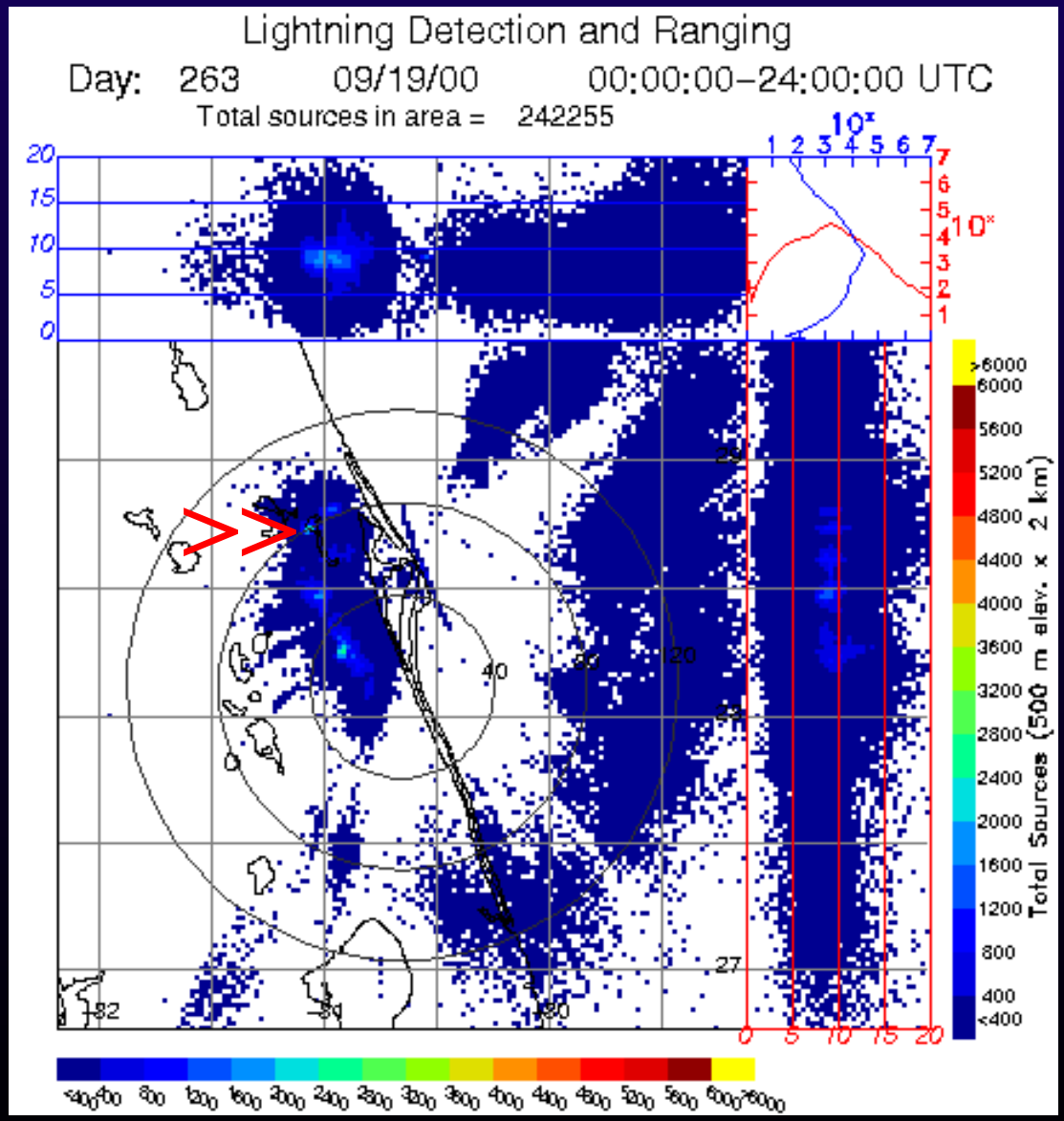
Max Refl. ~ 65 dBZ
(1928 UTC)

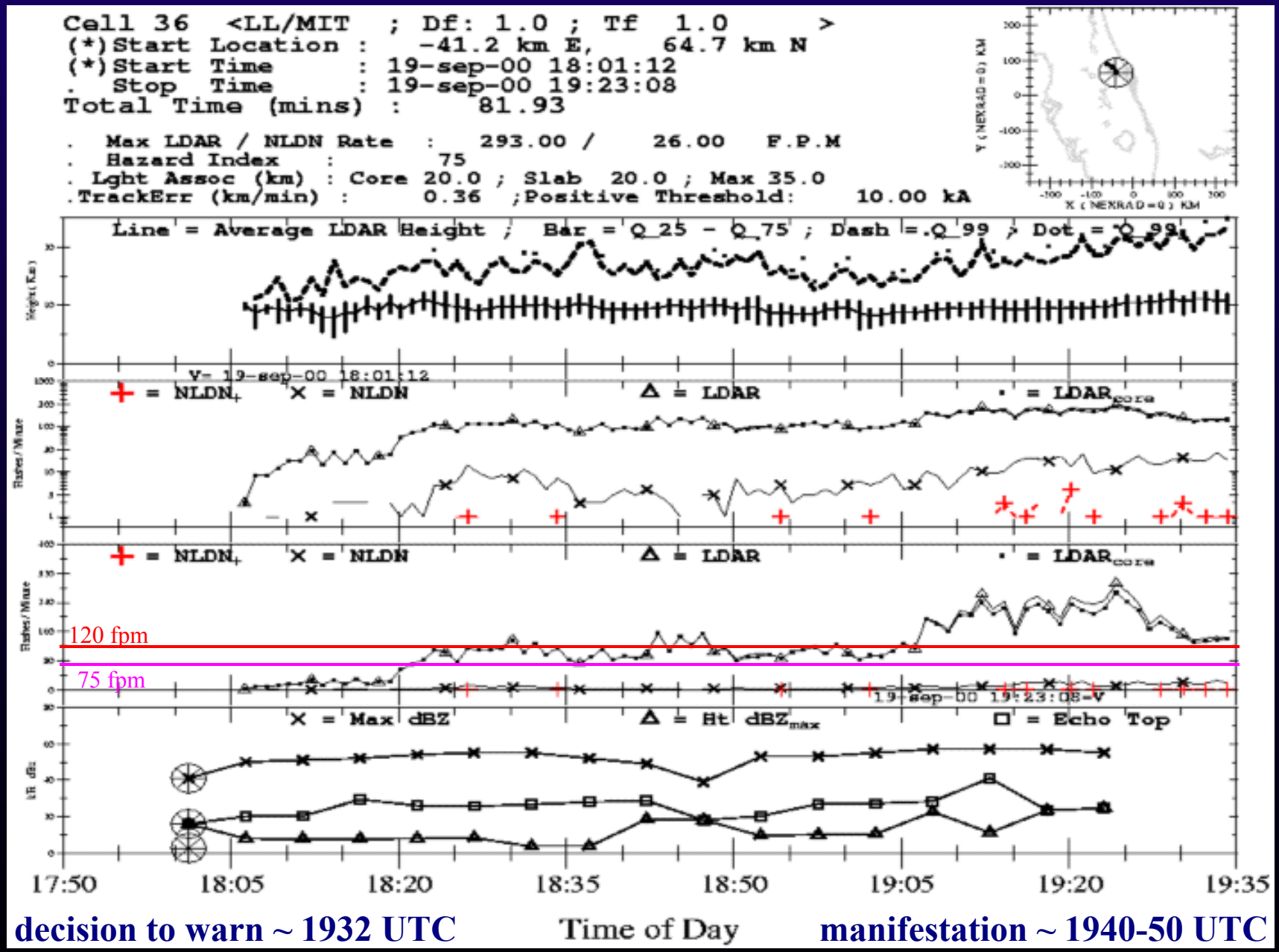


* Numerous downed trees and 1.75 inch hail

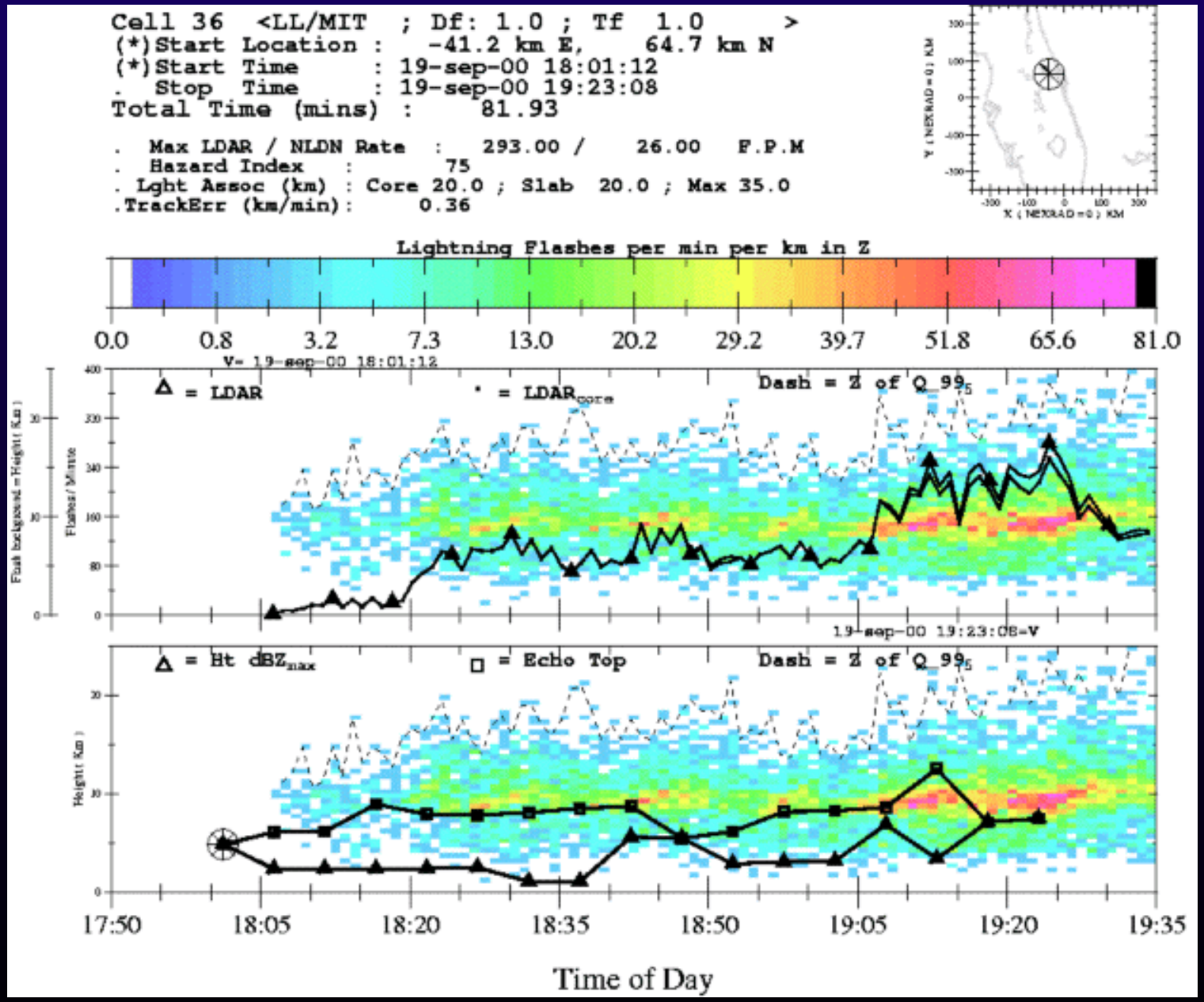
Max VIL ~ 70 kg/m^2
(1938 UTC)

LDAR Daily Summary



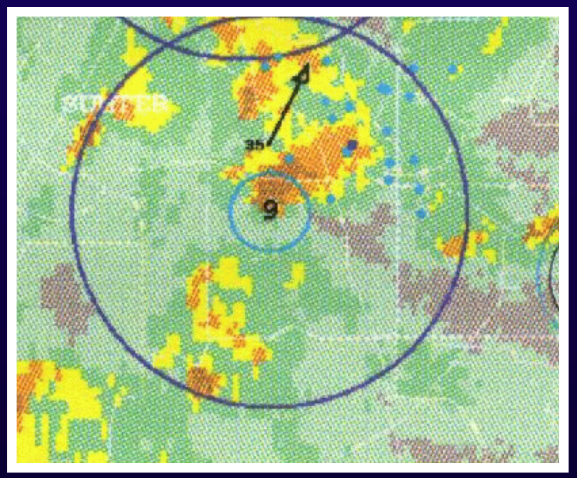


decision to warn ~ 1932 UTC Time of Day **manifestation ~ 1940-50 UTC**

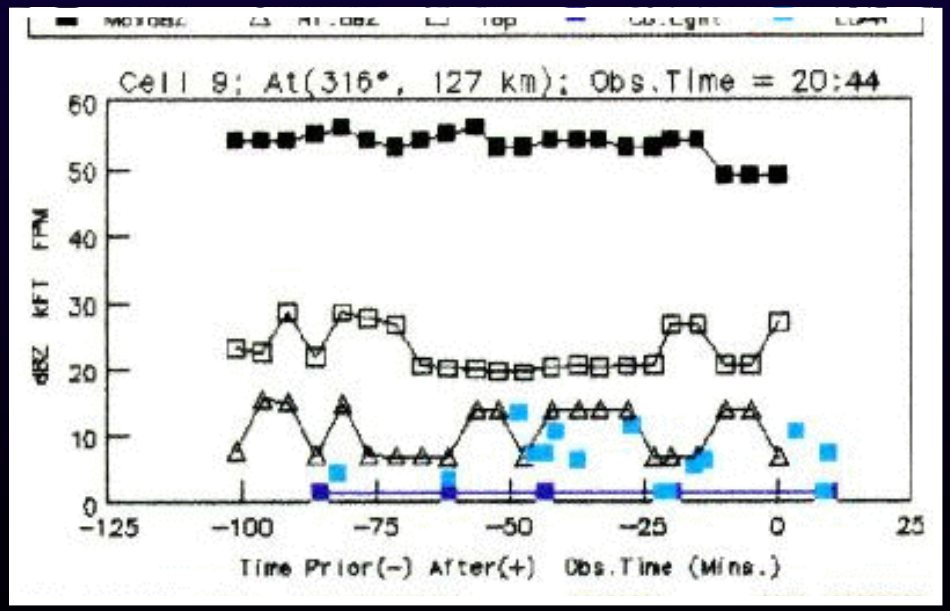

Cell 36 <LL/MIT ; Df: 1.0 ; Tf 1.0 >
(*)Start Location : -41.2 km E, 64.7 km N
(*)Start Time : 19-sep-00 18:01:12
. Stop Time : 19-sep-00 19:23:08
Total Time (mins) : 81.93
. Max LDAR / NLDN Rate : 293.00 / 26.00 F.P.M
. Hazard Index : 75
. Lght Assoc (km) : Core 20.0 ; Slab 20.0 ; Max 35.0
.TrackErr (km/min): 0.36
Lightning Flashes per min per km in Z
0.0 0.8 3.2 7.3 13.0 20.2 29.2 39.7 51.8 65.6 81.0
V- 19-sep-00 18:01:12
Δ = LDAR
• = LDAR core
Dash = Z of Q 99%
Flashes/Minute
19-sep-00 19:23:08-V
Δ = Ht dBZ max
□ = Echo Top
Dash = Z of Q 99%
Height (Km)
17:50 18:05 18:20 18:35 18:50 19:05 19:20 19:35
Time of Day

Tropical Cyclone Tornadoes

- Hazards
  - short-lived tornadoes
  - reoccurrence, families
- Warning Dilemma
  - radar detection limited
    - physical dimension
    - temporal nature or tornado
  - significant tornado
- Application
  - dominate outer band
  - tracer of "hybridness"
  - Non-descending & descending tornadoes
- Signals
  - existence, bursts

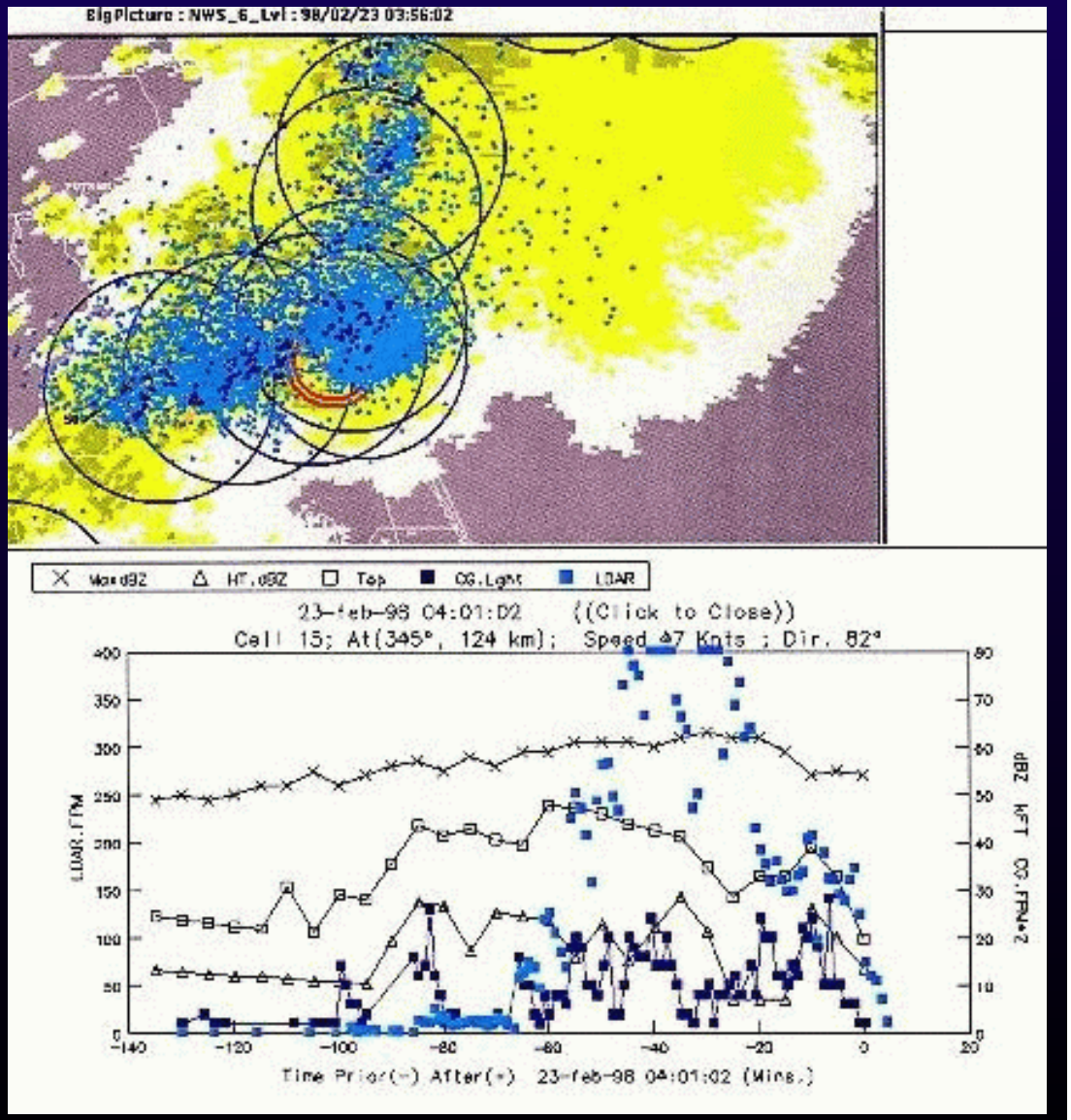


Josephine (1996)



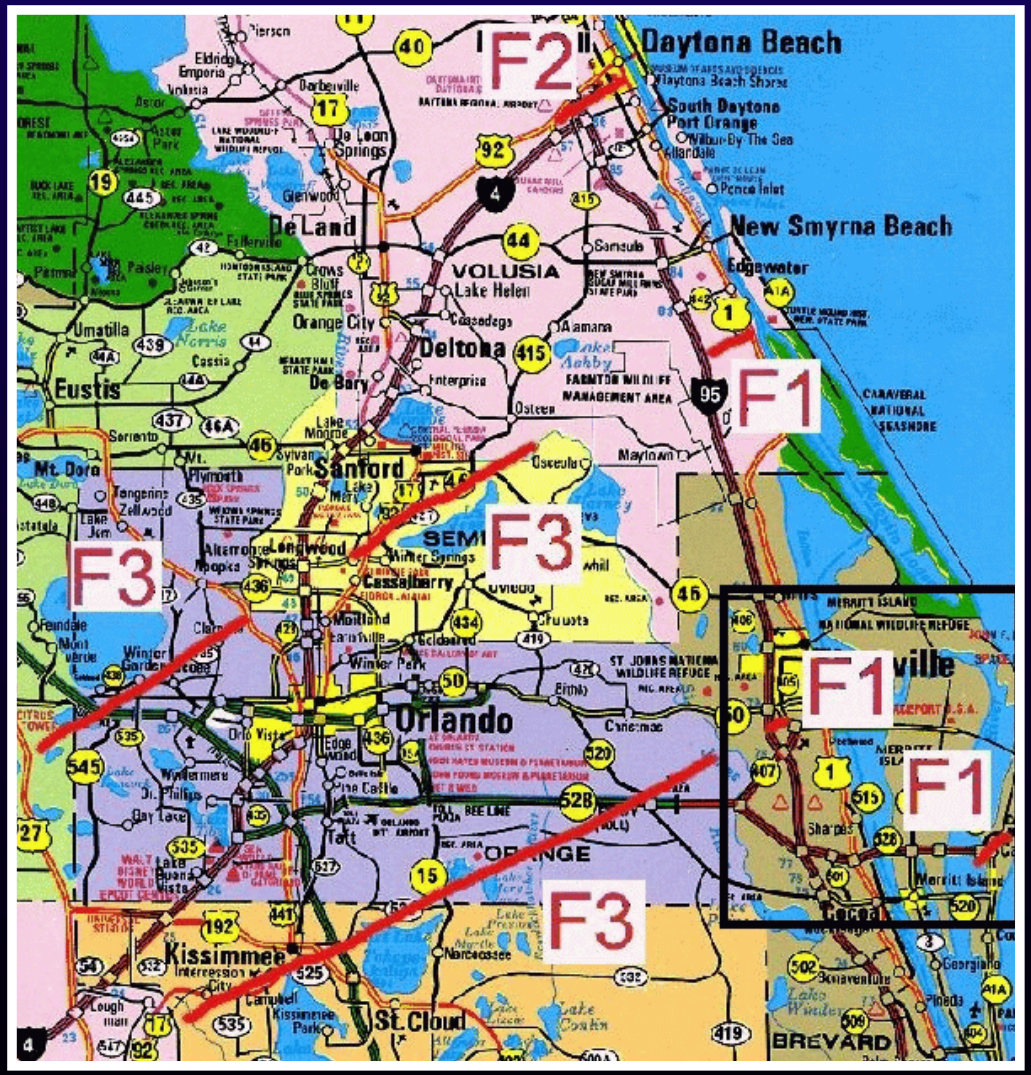
Extratropical Cyclone Tornadoes

- Hazards
  - strong/violent tornadoes
- Warning Dilemma
  - greatest threat to life
    - intensity
    - long-tracked
- Applications
  - discern tornadic from non-tornadic
  - not just severe from non-severe
- Signals
  - higher relative rate
  - lightning “jump”
  - lightning “drop”

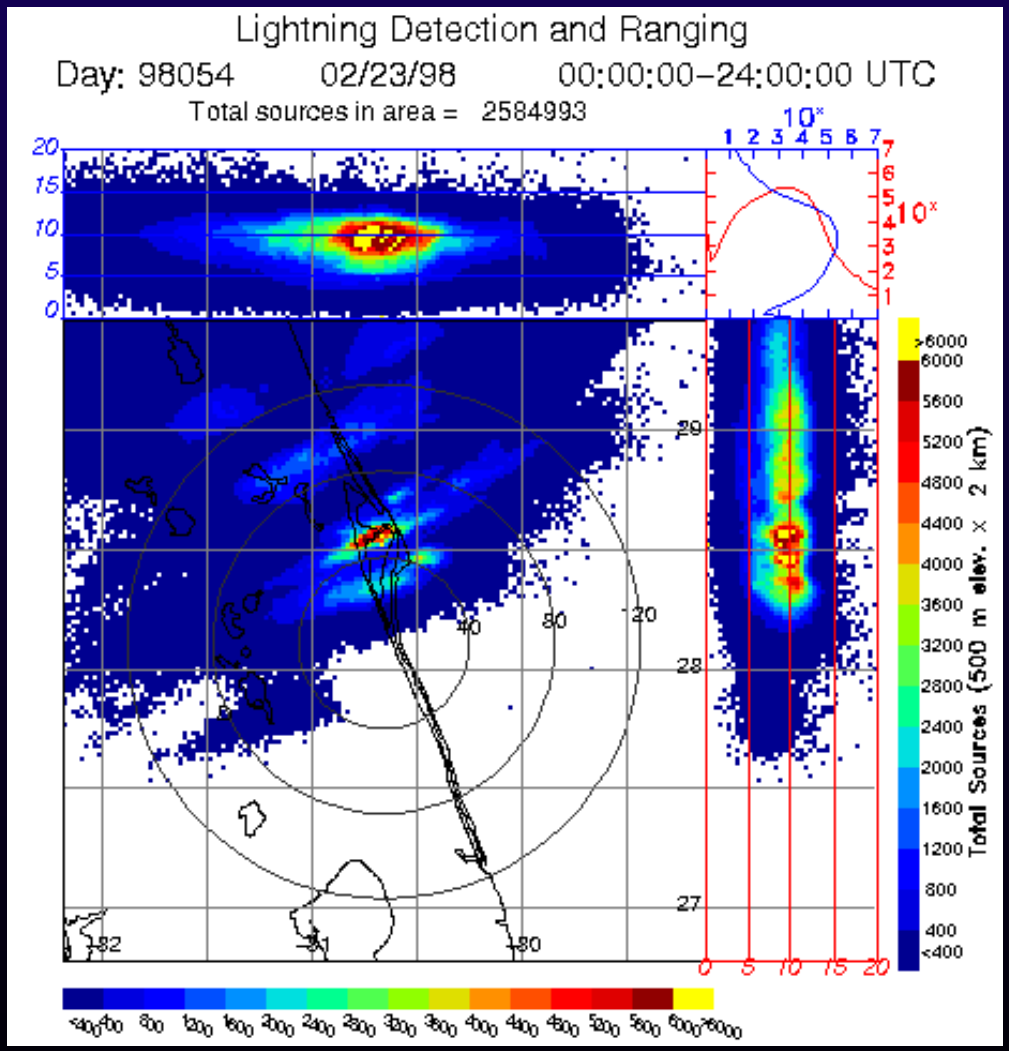


East Central Florida Tornado Outbreak

- During the tornado outbreak (02/22-23/98), seven tornadoes occurred associated with four "supercells".
- Also, a long-tracked F3 tornado occurred over extreme eastern Orange County before lifting at the Brevard County line.

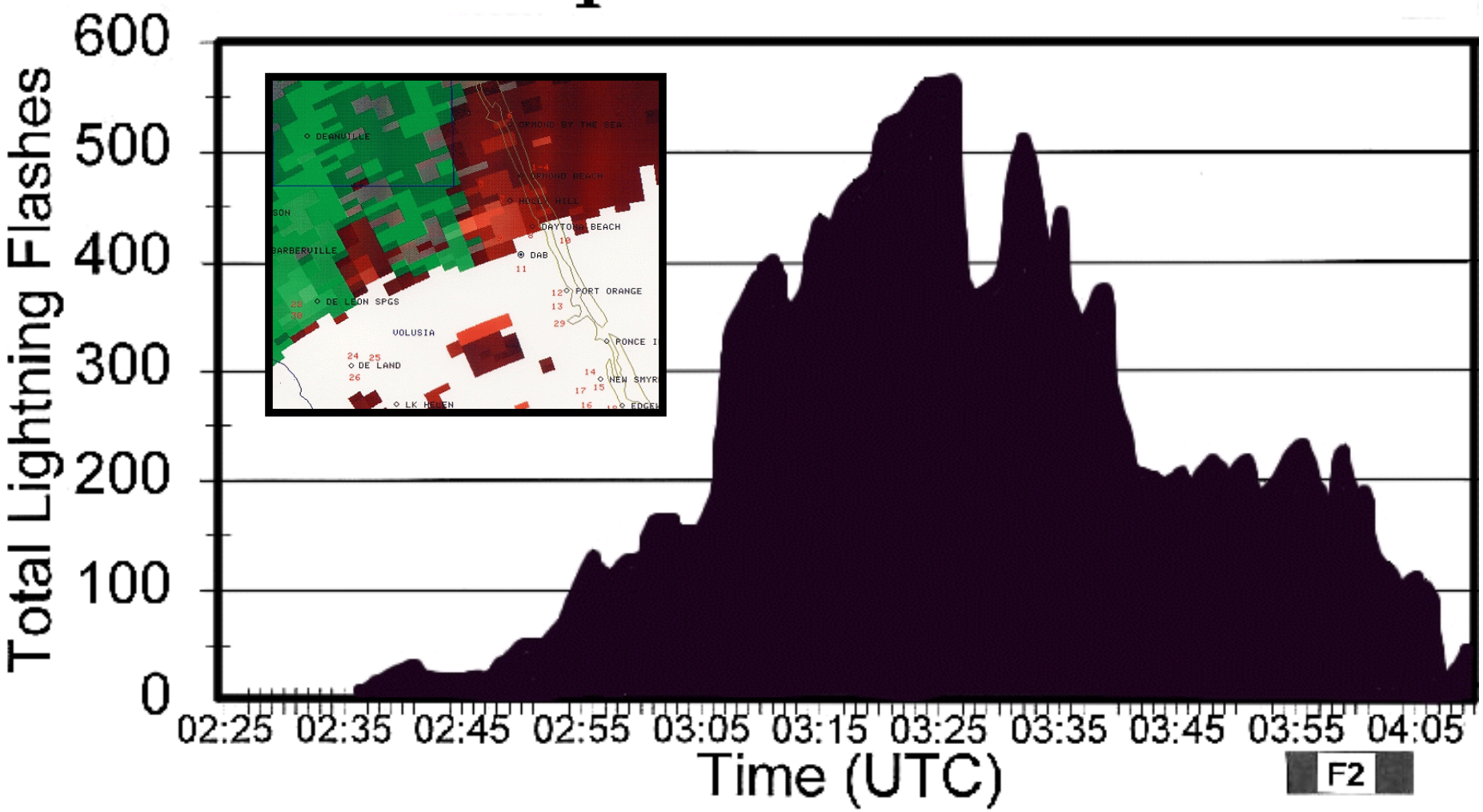


LDAR Daily Summary

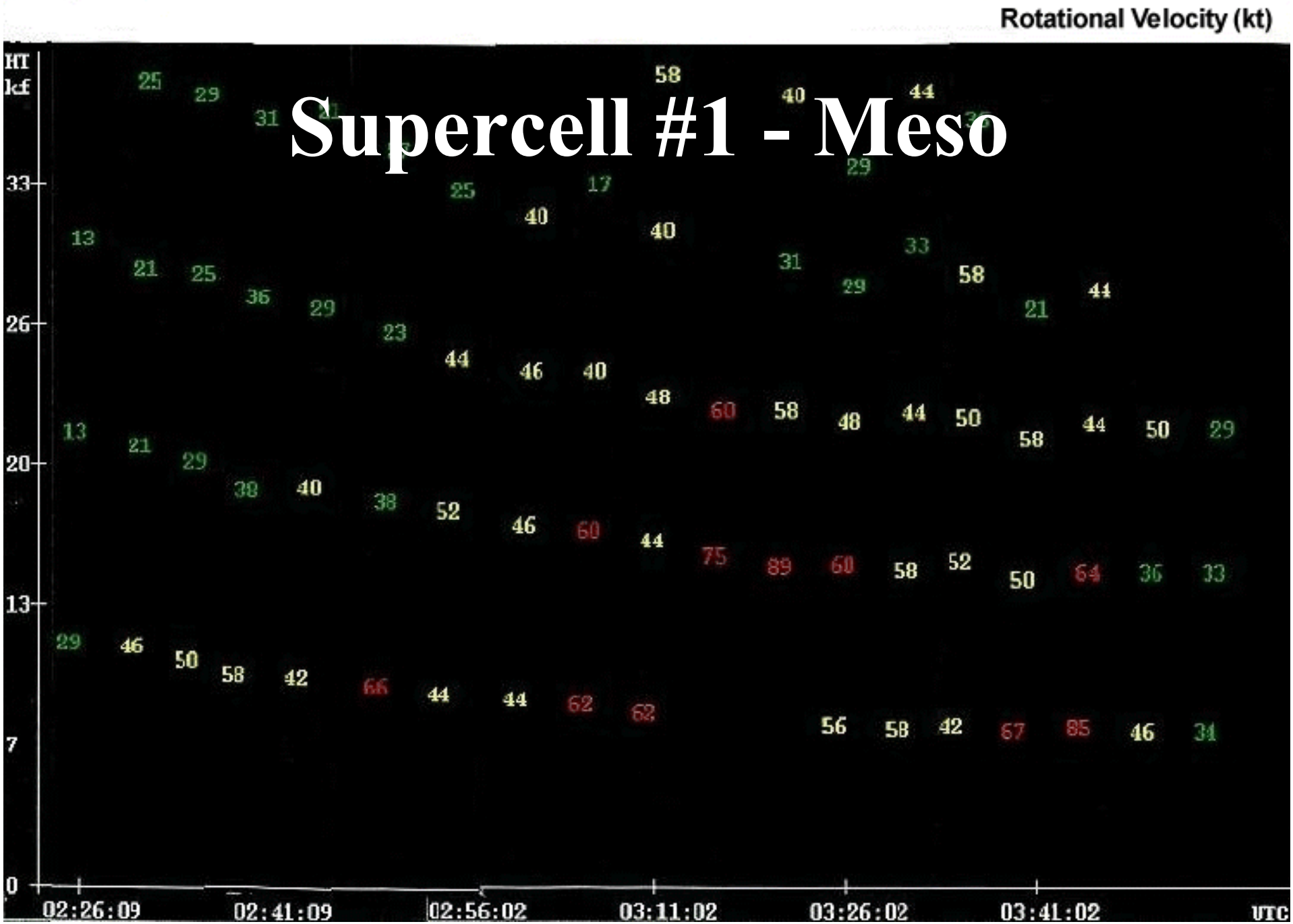


Note the tracks.

Supercell #1



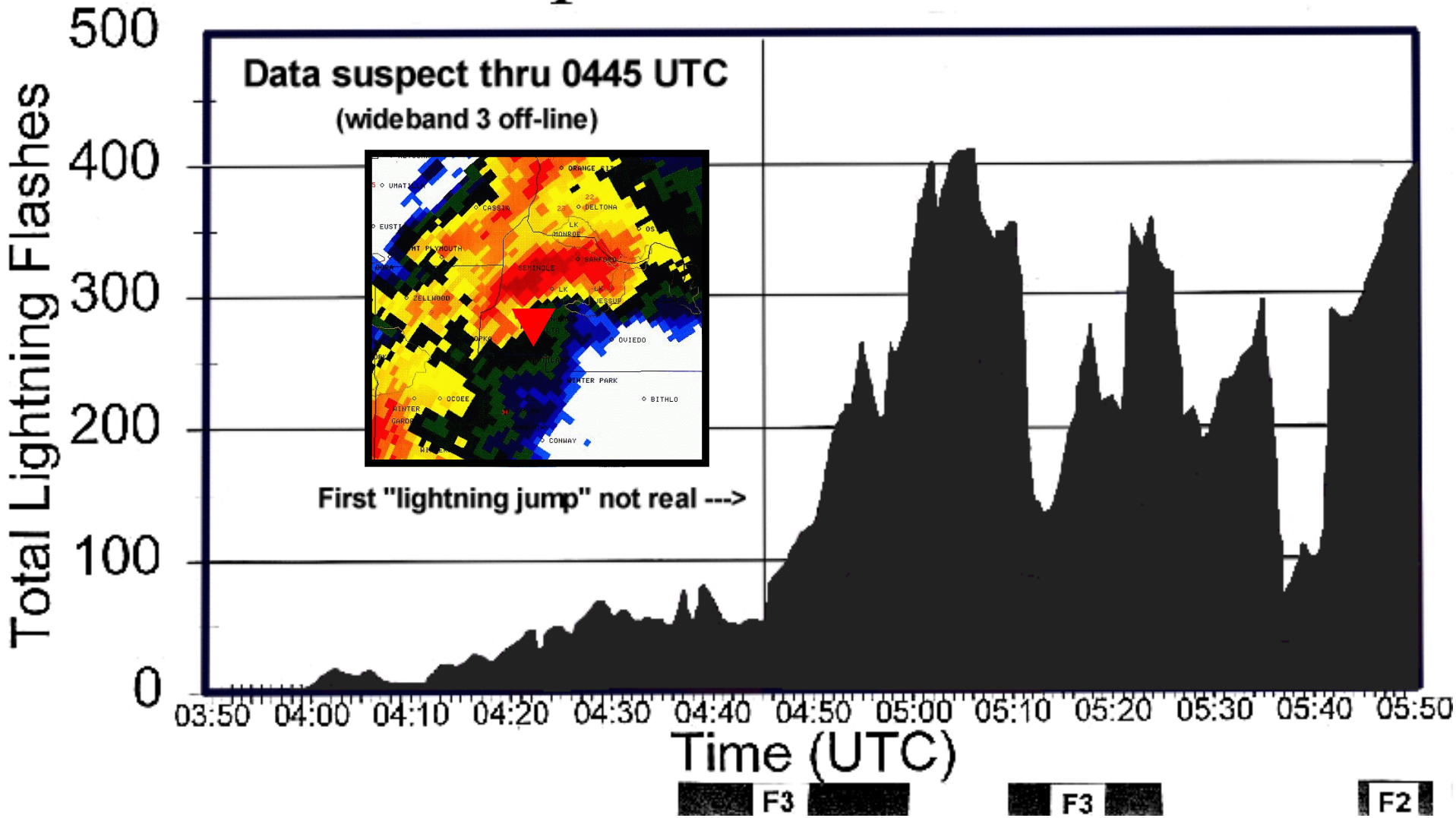
= Hail/Wind Damage


Rotational Velocity (kt)
Supercell #1 - Meso
HT
kf
33
26
20
13
7
0
02:26:09
02:41:09
02:56:02
03:11:02
03:26:02
03:41:02
UTC

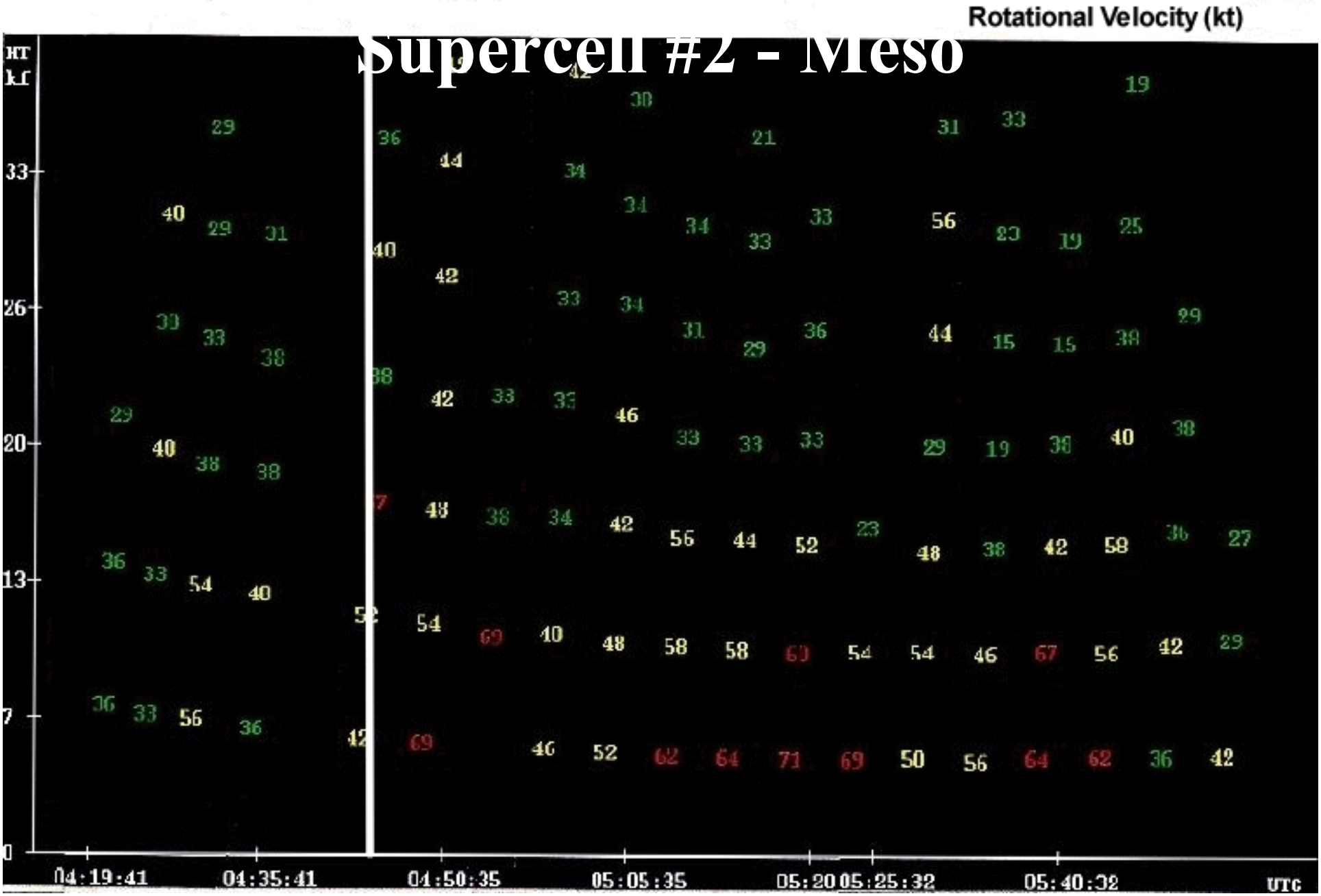
Observations

- Supercell #1
  - Achieved minimum flash rate threshold (relative)
  - Experienced lightning jump well before tornado
  - Experienced a dramatic lightning drop just before tornado as angular momentum aloft descended towards surface

Supercell #2


Data suspect thru 0445 UTC
(wideband 3 off-line)
First "lightning jump" not real --->
Total Lightning Flashes
500
400
300
200
100
0
03:50
04:00
04:10
04:20
04:30
04:40
04:50
05:00
05:10
05:20
05:30
05:40
05:50
Time (UTC)
F3
F3
F2

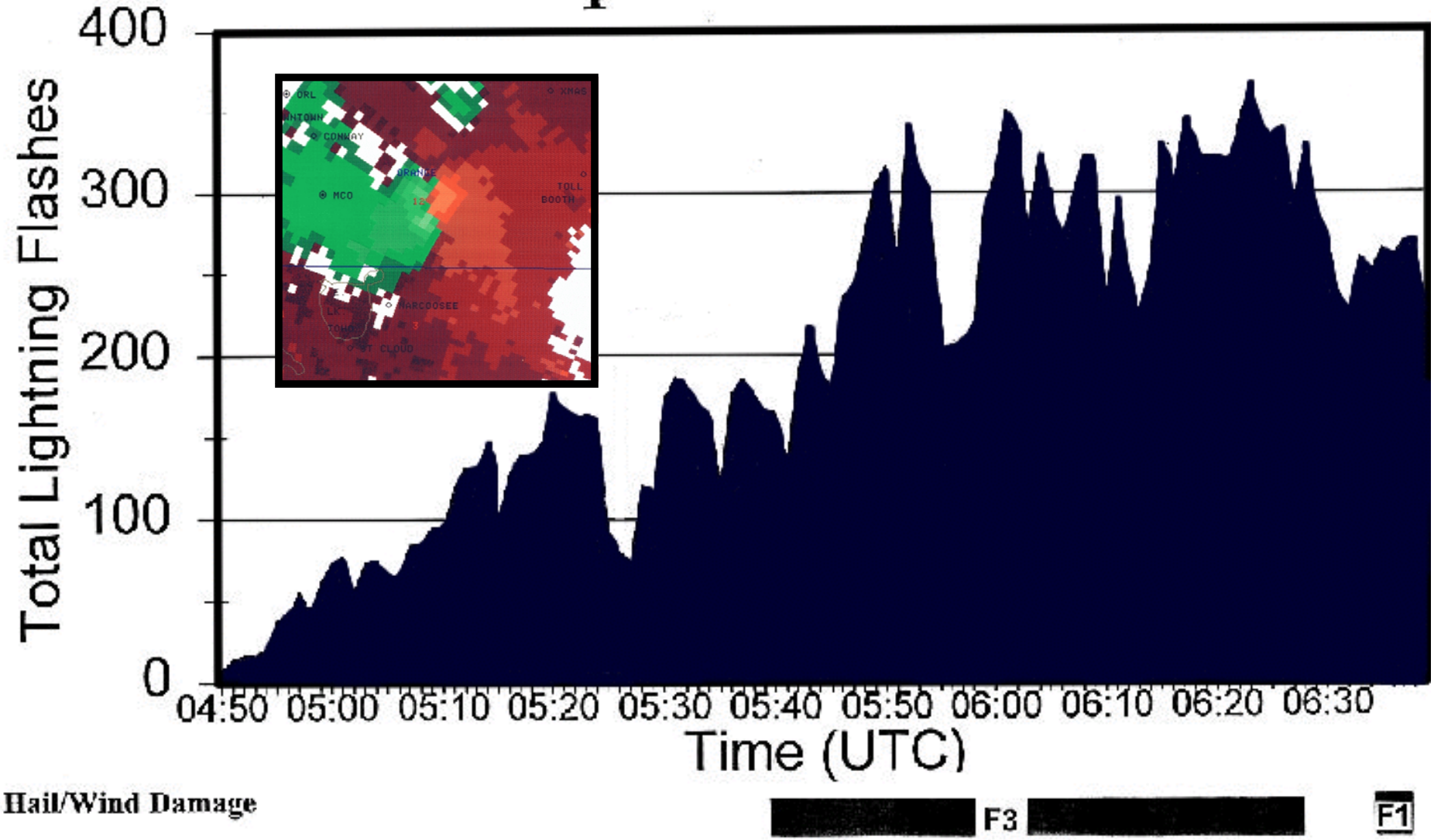
Supercell #2 - Meso



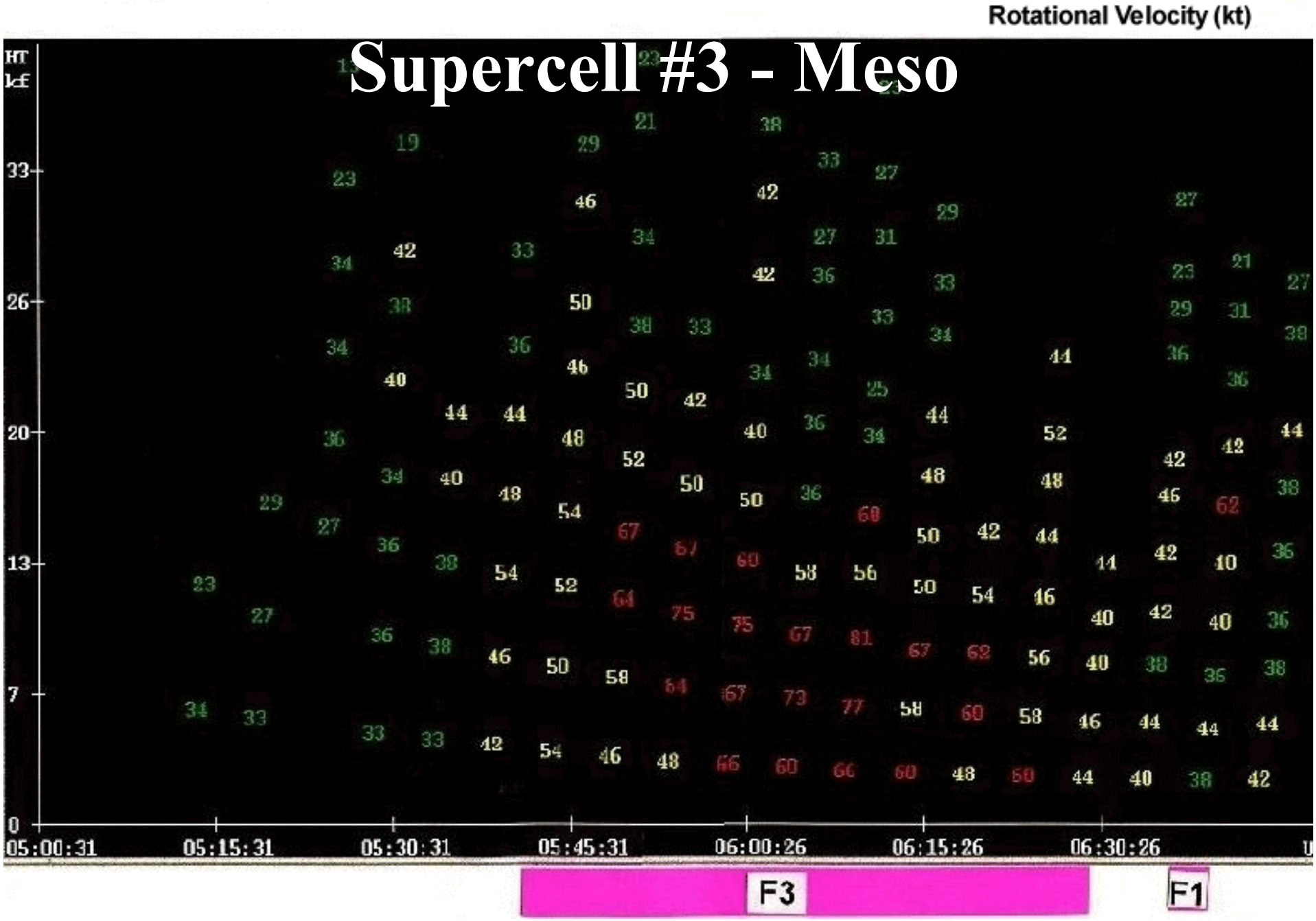
Observations

- Supercell #2
  - Achieved minimum flash rate
  - Cyclic mesocylogenesis (3 tornadoes)
  - Lightning jump well before each tornado (except unknown for first tornado)
  - Lightning drop just before each tornado
  - Interestingly, flash rates increased during 2nd & 3rd tornadoes (flash rates with old and new cores added together??)

Supercell #3


Total Lightning Flashes
400
300
200
100
0
04:50 05:00 05:10 05:20 05:30 05:40 05:50 06:00 06:10 06:20 06:30
Time (UTC)
ORL
XMAS
CONWAY
MCO
TOLL BOOTH
NARCOOSEE
ST CLOUD
= Hail/Wind Damage
F3
F1

Supercell #3 - Meso

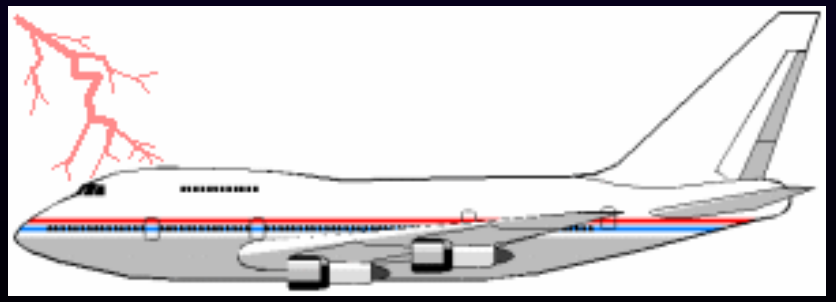


Observations

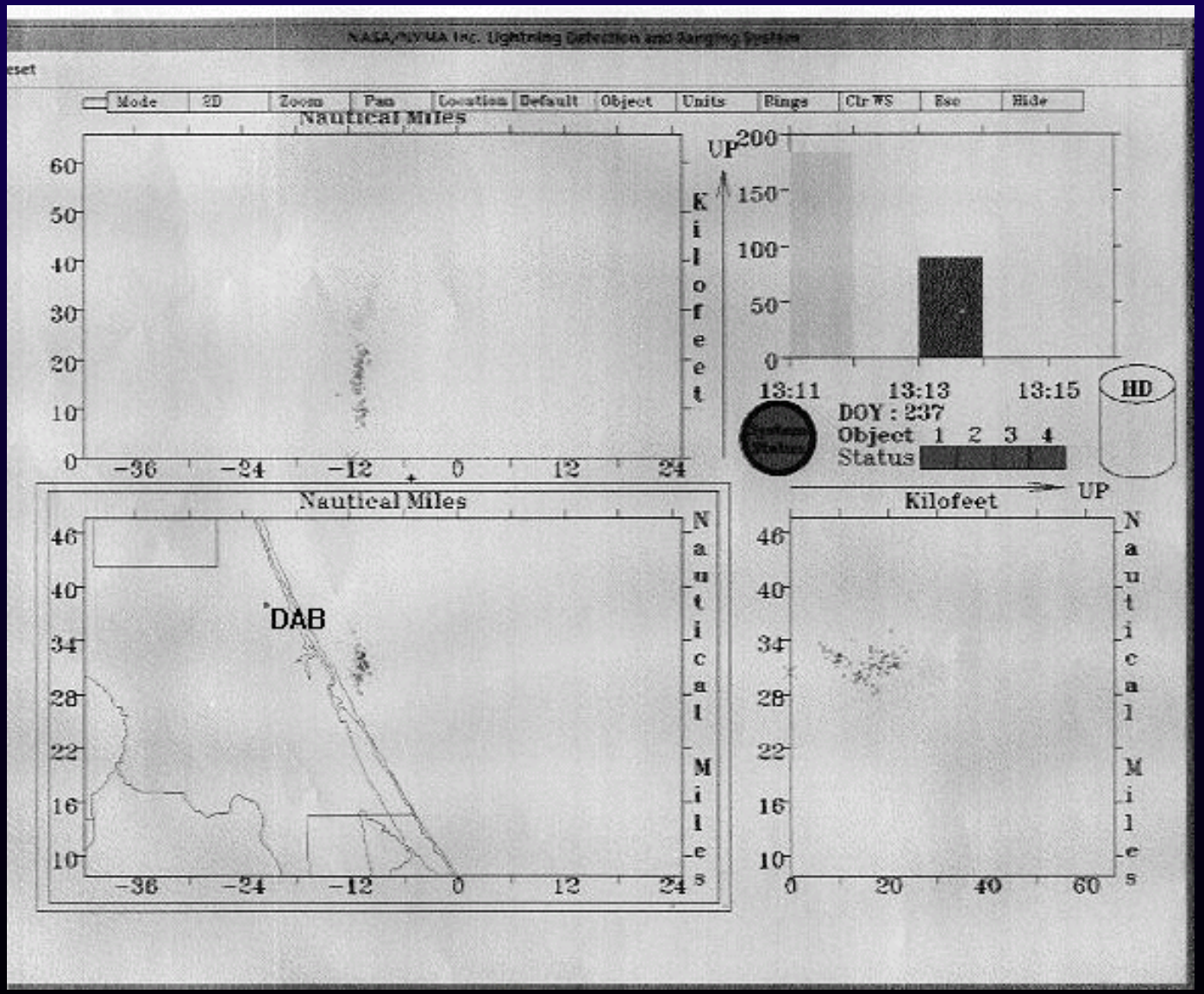
- Supercell #3
  - Achieved minimum flash rate (relative)
  - Sustained minimum flash rate (for a very long time !)
  - Flash rate increased during time of tornado
  - Most persistent/intense mesocyclone with long-track tornado

Improved Aviation Forecasts

- Terminal Aerodrome Forecasts (TAFs) for MCO, DAB, MLB, and VRB
- The inclusion/removal of "TS" (and associated IFR ceilings & visibilities) in prevailing or TEMPO group and optimized use of "VCTS"
- Improved forecasts and/or timely amendments
  - 0-2 hour forecast time frame
  - Early detection of TLI before first CG
  - Continuation of TLI after final CG
  - Cases where there is little to no CG signal
  - Anvil Lightning

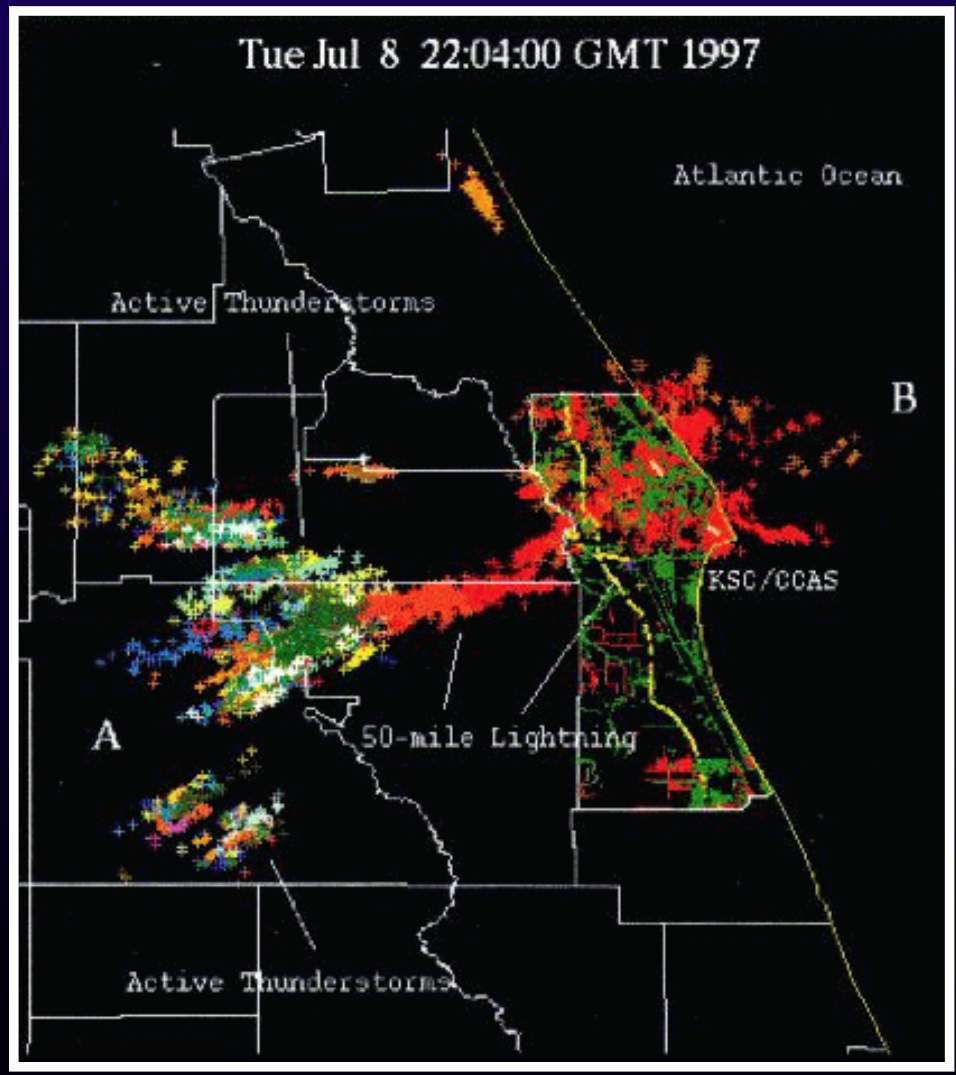


Little to No CG Signal

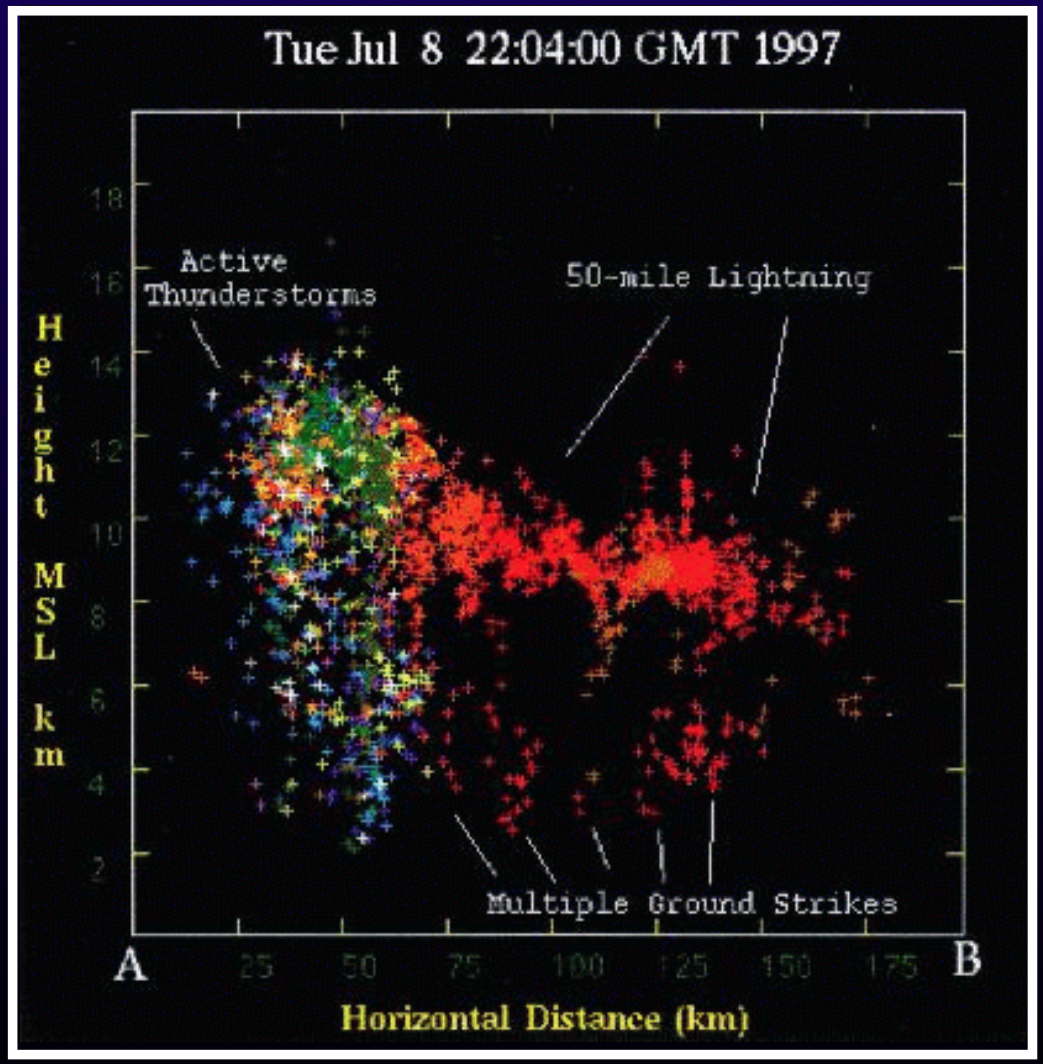


Anvil Lightning

- Charged cloud debris from decayed storm with excited IC activity from current storm.
- Debris still precipitating (but not reaching the surface in this case).
- CG discharge under debris cloud away from main storm.

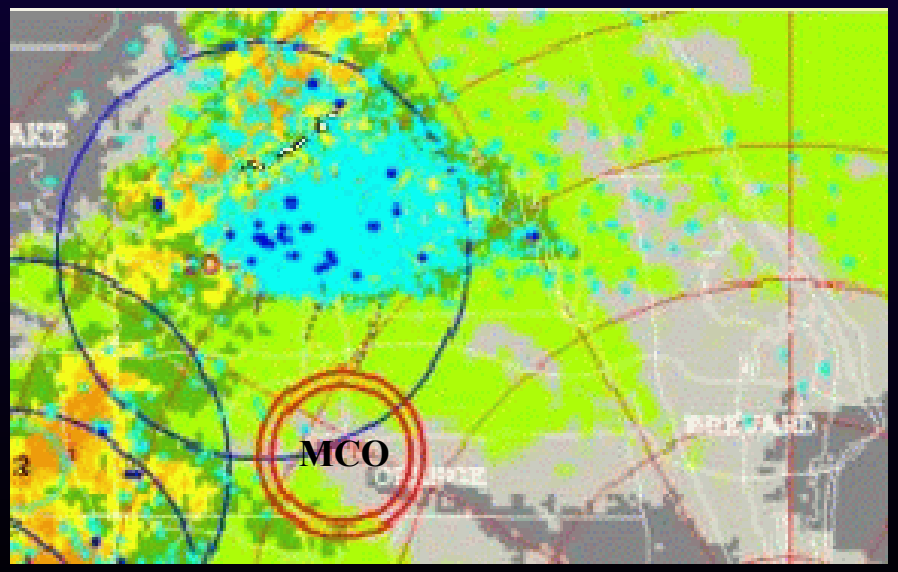


Anvil Lightning

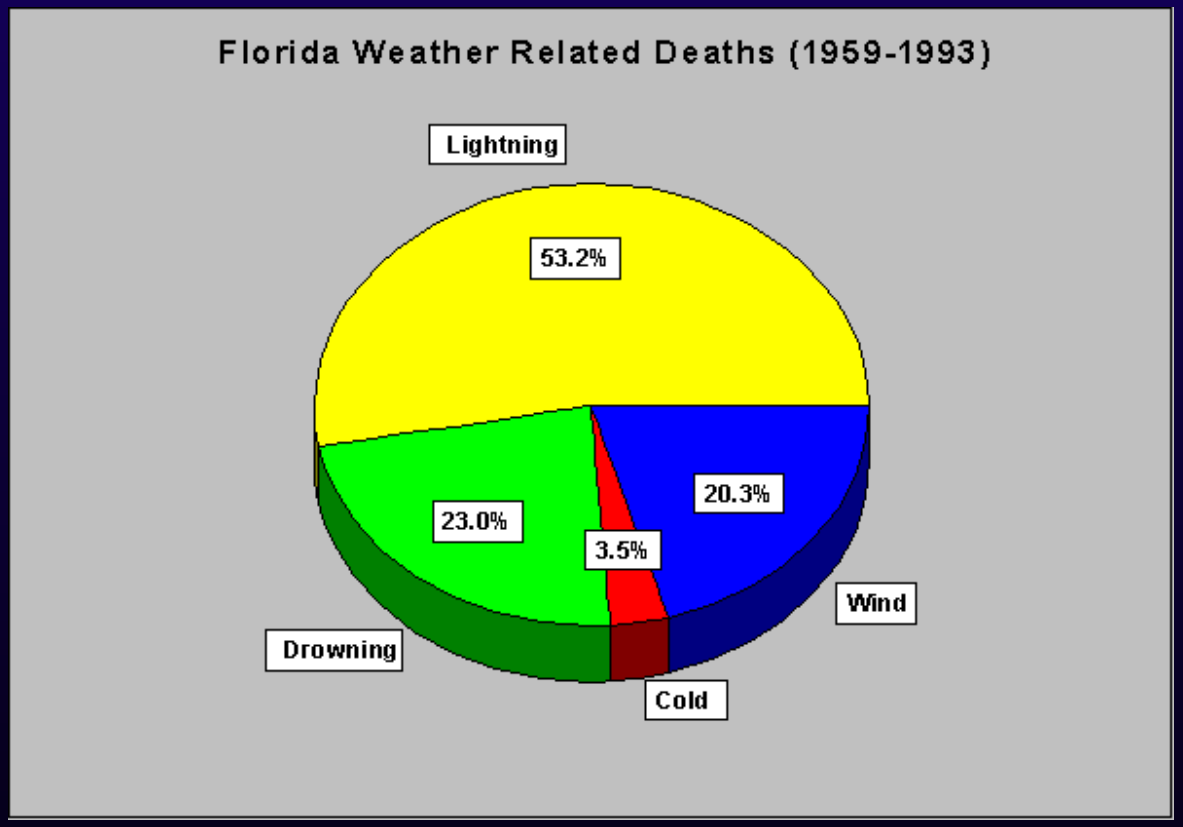


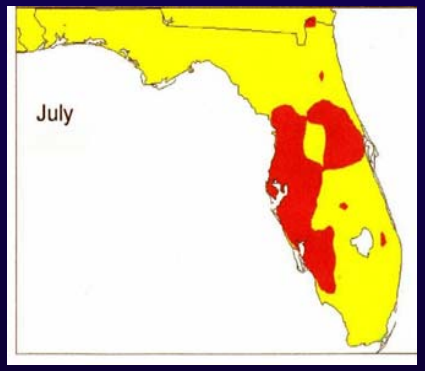
Alerting Areas

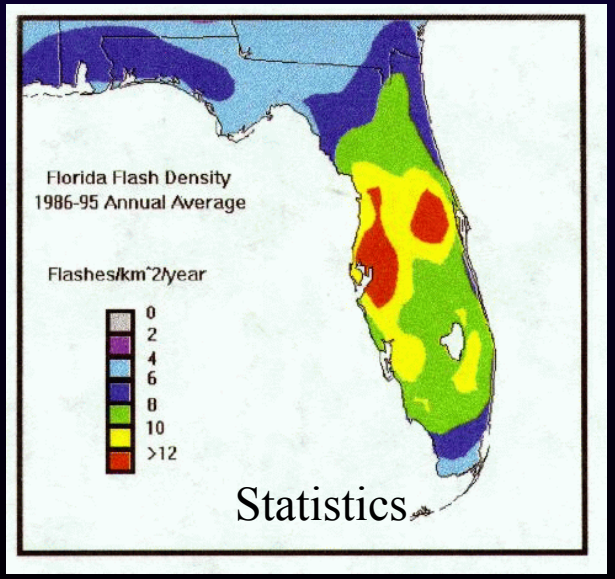
- Circle icon around Airport/TAF site (color-coded)
- Black = no TLI within 20 nmi
- Cyan = TLI within 20 nmi;
  not within 10 nmi
- Yellow = TLI within 10 nmi;
  Not within 5 nmi
- Red = TLI within 5 nmi
- 15 minute safety lag
  before retreating to
  next higher level
- Airport Advisories for
  ground operations



Need Lightning Products & Services







Expressions from the Statistics

- Relative to the period of peak flash, more people are struck by lightning either before or afterwards.
- This means that the first & last CG strikes are the concern.
- Also, people were more likely to get struck by lightning from storms containing occasional or frequent lightning, not excessive lightning (they don't feel as threatened).
- People live in the geo-relative world, not storm relative.
- Property damage was more extensive with storms having excessive lightning (more opportunity).

"LIGHTNING STORM"

- During peak lightning season (June - Sept)
  - Supported by climatology & casualty statistics
  - Mainly emphasized during the day
  - Emphasized when "excessive" level is achieved for a given storm

- During the remainder of the year
  - When "excessive" level is achieved for a given storm

...only when lightning is the primary hazard !!!

Provide More Information

Quantify lightning information in Short Term Forecasts

OCCASIONAL: 1-3 CG strikes per minute

FREQUENT: 4-11 CG strikes per minute

EXCESSIVE: 12+ CG strikes per minute

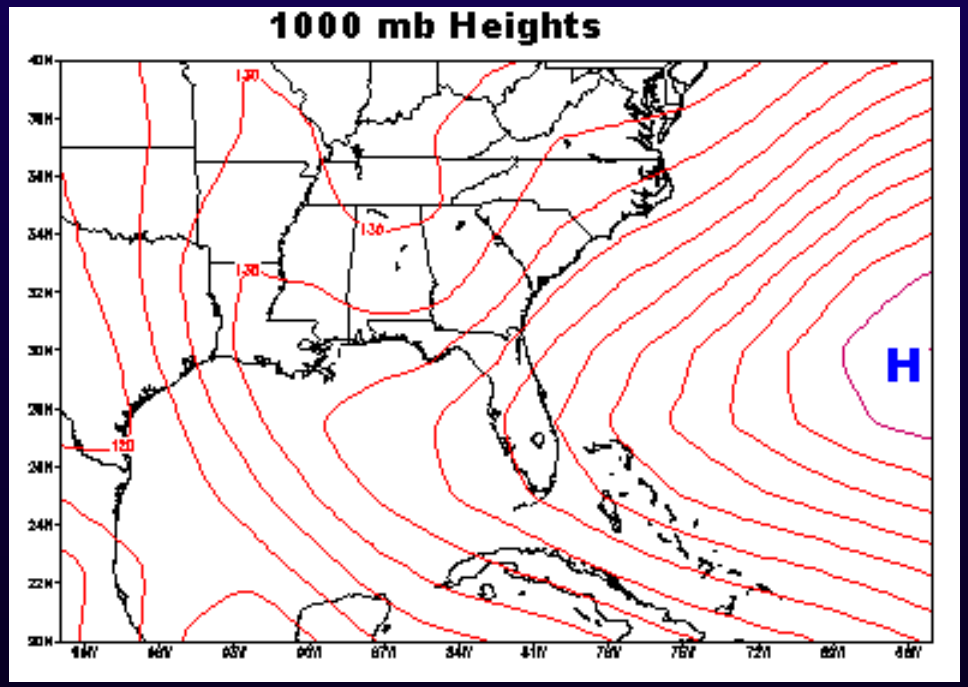
Hazardous Weather Outlook

...EXCESSIVE LIGHTNING EXPECTED OVER THE COASTAL COUNTIES OF EAST CENTRAL FLORIDA...

WITH THE ATMOSPHERE OVER CENTRAL FLORIDA REMAINING MOIST AND UNSTABLE...DEADLY LIGHTNING STORMS WILL DEVELOP OVER THE AREA AGAIN THIS AFTERNOON. SINCE THE HIGH PRESSURE RIDGE AXIS WAS LOCATED SOUTH OF CENTRAL FLORIDA...THE SURFACE WINDS WILL BE FROM WEST. THEREFORE...*THE EARLIEST OCCURRENCES OF CLOUD-TO-GROUND LIGHTNING* WILL BE OVER INTERIOR SECTIONS IN VICINITY OF LEESBURG... SANFORD... ORLANDO... AND KISSIMMEE DURING THE EARLY AFTERNOON. AS THE AFTERNOON PROGRESSES... *LIGHTNING STORMS WILL INCREASE IN NUMBER* AND CLUSTER TOWARDS THE EAST COAST WHERE THE EAST AND WEST COAST SEA BREEZES ARE EXPECTED TO COLLIDE LATE IN THE AFTERNOON. *EXCESSIVE LIGHTNING AT A RATE EXCEEDING 12 STRIKES PER MINUTE* WILL LIKELY OCCUR WITH SEVERAL STORMS FROM DAYTONA BEACH...TO COCOA BEACH...TO VERO BEACH...TO FT PIERCE. LIGHTNING WILL APPROACH THESE LOCATIONS FROM THE WEST.

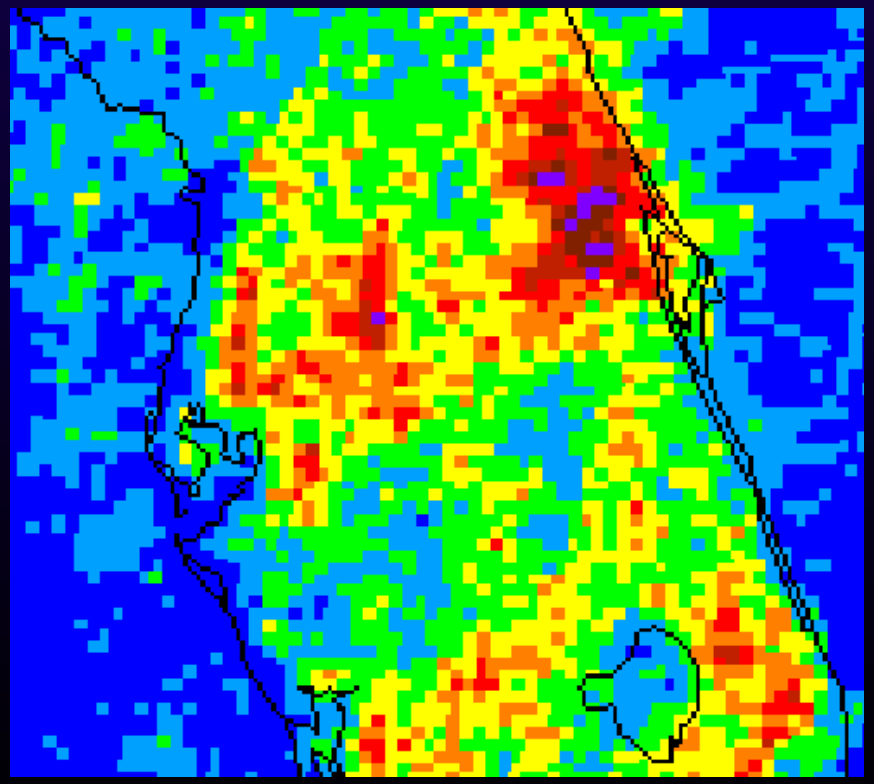
Flash Density & Frequency

(Lericos et al.)



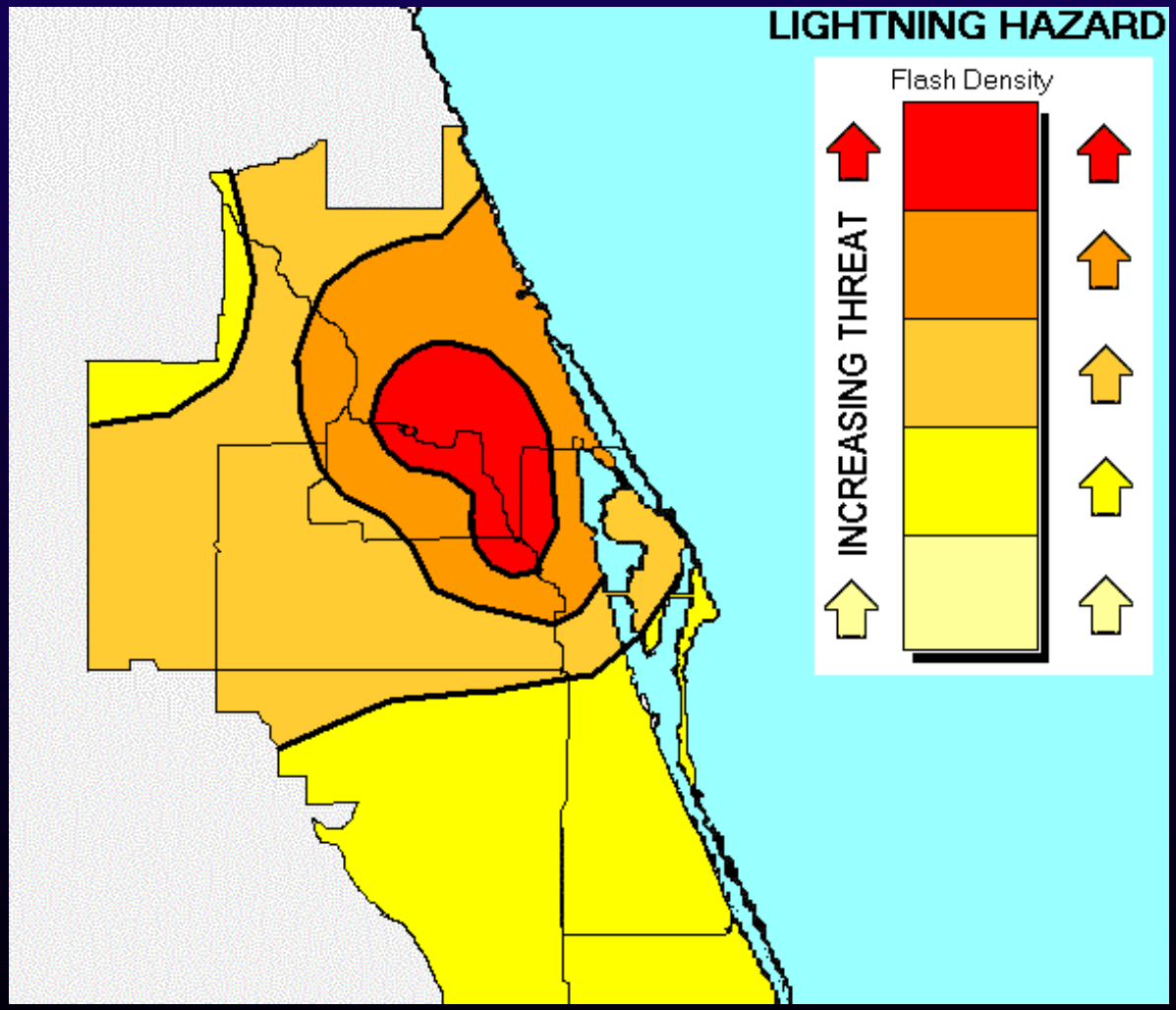
Flow Regimes

Flash Density Distribution



* Also good for GFE use.

Lightning Threat Graphics



Short-term Forecast

SHORT TERM FORECAST...

...STORMS PRODUCING *FREQUENT CLOUD TO GROUND LIGHTNING* WILL BE POSSIBLE FROM KISSIMMEE/ST CLOUD... TO ORLANDO AND SANFORD. AN ISOLATED LIGHTNING STORM WILL ALSO MOVE NORTH ALONG...

Frequent - 4 to 11 cloud to ground strokes per minute

Short-term Forecast

SHORT TERM FORECAST...

BY 2PM...A LINE OF STRONG LIGHTNING STORMS WILL APPROACH THE GREATER DAYTONA BEACH.

SOME OF THESE STORMS WERE PRODUCING DANGEROUS *CLOUD TO GROUND LIGHTNING WELL AWAY FROM THE HEAVY RAIN*. BEACH-GOERS ARE URGED TO TAKE SHELTER INDOORS WELL BEFORE THE RAIN APPROACHES THE AREA FROM THE WEST.

CG Onset Time/Location

Forecasters should attempt to issue short-term forecasts in advance of the initial CG strikes over "sensitive" areas.

SHORT TERM FORECAST...

...CLOUD TO GROUND LIGHTNING WILL BEGIN OVER COASTAL INDIAN RIVER COUNTY BY 11 AM...

Excessive Lightning SPS

...EXCESSIVE LIGHTNING STORM OVER BREVARD COUNTY...

THROUGH 6 PM EDT... *A STORM PRODUCING EXCESSIVE LIGHTNING* WILL AFFECT PARTS OF BREVARD COUNTY FROM NEAR TITUSVILLE... TO THE KENNEDY SPACE CENTER... TO PORT CANAVERAL AND COCOA BEACH. *THIS STORM WAS PRODUCING GROUND STRIKES AT THE RATE OF 12 TO 15 PER MINUTE AND IS ESPECIALLY DANGEROUS.* THOSE WITH THE GREATEST DANGER ARE PEOPLE IN NORTH BREVARD COUNTY ENGAGED IN OUTDOOR ACTIVITIES SUCH AS BOATING, SWIMMING, OR PLAYING GOLF. DUE TO THE GREATER NUMBER OF STRIKES...THERE IS AN *INCREASED THREAT TO LIFE* IF LIGHTNING SAFETY RULES ARE NOT FOLLOWED. THE EXCESSIVE FREQUENCY OF STRIKES WILL ALSO BRING A GREATER CHANCE FOR DISRUPTION IN ELECTRICAL POWER SERVICE AND *RELATED PROPERTY DAMAGE*.

Questions ???

Thank You!!!

National Weather Service
Melbourne, FL

"We're turning science into a service,
while turning service into a science."

Lightning “Jump”

A ***lightning "jump"*** was defined as a steady increase in the total flash rate of at least 50 flashes over an observed period of time. The "jump" ends when 2 consecutive 1-minute flash rates are less than, or equal to, the previous 1-minute flash rate."

The larger the jump...

The faster the jump...

(also the “drop”)